

ORIGINAL

ADAMS BROADWELL JOSEPH & CARDG

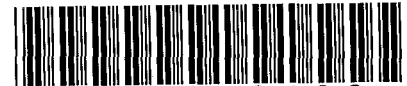
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2002 APR -2 A 10:31
AZ CORP COMMISSION
DOCUMENT CONTROL

April 1, 2002

VIA FEDERAL EXPRESS

Docket Control
Arizona Corporation Commission
1200 West Washington Street
Phoenix, AZ 85007

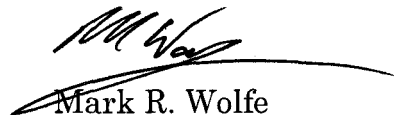
Re: Allegheny Energy Supply Company, LLC
Docket No. L-00000AA-01-0116; Case No. 116

Dear Sir/ Madam:

With this letter, Arizona Unions for Reliable Energy files ten copies of the following document in the above-referenced Docket:


AZURE Letter to Chairman William A. Mundell (4/1/02)
Containing requested ZLDC and U2A information

Sincerely,


Mark R. Wolfe

Arizona Corporation Commission
DOCKETED

APR 02 2002

DOCKETED BY	
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1257a-037

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April 1, 2002

VIA FEDERAL EXPRESS

Chairman William A. Mundell
Arizona Corporation Commission
1200 West Washington Street
Phoenix, AZ 85007

Re: Allegheny Energy Supply Company, LLC
Docket No. L-00000AA-01-0116

Dear Chairman Mundell:

During the March 21, 2002 public meeting and oral arguments in the Allegheny Energy Supply/La Paz Generating Facility siting case referenced above, you requested further information regarding: (1) whether a zero liquid discharge crystallizer system ("ZLDC") would generate hazardous waste requiring handling and disposal under the laws and regulations governing hazardous waste; and (2) whether there existed research or information addressing the load-following capabilities of urea-to-ammonia ("U2A") systems on natural gas-fired powerplants operating in merchant mode, as opposed to baseload plants. We hope you find the following information responsive and informative.

1. A ZLDC For The La Paz Project Would Not Generate Hazardous Waste.

As proposed by the applicant, the project's cooling tower blowdown and other waste streams would be discharged to sixty acres of evaporation ponds. As the liquid component of the blowdown evaporates into the atmosphere, it leaves solids behind in the form of sludge. As the ponds fill up with this material, the solids must be excavated and disposed of in landfill.

A ZLDC essentially performs the same function as the ponds: it evaporates water, leaving behind solids. The difference is that the ponds use solar energy to

1257a-036

April 1, 2002

Page 2

evaporate water, while a ZLDC system uses electricity in a brine concentrator and a crystallizer to evaporate water. The solids left behind by a ZLDC do not differ in chemical composition to those left behind in evaporation ponds. In addition, a ZLDC system results in fewer solids requiring disposal, because it generates pure water that can be recycled back into the plant, thereby reducing the demand for additional water.

To AZURE's knowledge, none of the power plant projects using ZLDCs in California are generating hazardous waste. Based on the groundwater quality data presented in the CEC application for this project, it does not appear that the crystallized solids generated from a ZLDC for the La Paz facility would be hazardous, and the applicant has not indicated that its pond solids would be.

For your information, we are attaching copies of two exhibits AZURE submitted previously with its comments on the Big Sandy Project Environmental Impact Statement (Attachment 1). These materials, which should already be in the Commission's files, describe the use and widespread adoption of ZLDCs. We are also attaching an excerpt from Calpine's license application, submitted to the California Energy Commission, for the San Joaquin Valley Energy Center, a 1,060 MW combined-cycle plant to be located near Fresno, California. (Attachment 2.) This excerpt provides a good description of the operation and use of a ZLDC system.

2. U2A Systems In Operation At Merchant Power Plants Show No Load Following Problems

In response to your request for more information regarding U2A systems, we are providing a copy of a technical paper (Attachment 3) reviewing the current state of U2A technology, with an emphasis on test results from a demonstration on the AES Alamitos generating station in Southern California, a swing-load (non-baseload) unit. Prepared by EC&C Technologies, the inventor of the U2A system, the paper describes the process for ammonia generation, and presents the results of a real-time study performed at the AES Alamitos facility. As reported on pages 12 – 13, the system showed no load following problems, and "at all times during the U2A automatic control operation the NO_x emissions and NH₃ were maintained within compliance set points determined in the plant DCS." The report also documents how the U2A process "provides simple control and load following response including design to accommodate maximum ramping rates that are derived from consideration of the maximum rate of increase of boiler load, the flue gas mass flow vs. boiler load and then NO_x concentration as a function of boiler load." (See p. 13.)

April 1, 2002

Page 3

We have also learned that AES has over 5,000 hours of operating experience with U2A at two merchant generating units at the Huntington Beach Generating Station and will soon start up two additional merchant units equipped with U2A. These units experience load swings from 10 MW to 200 MW. They have informed the U2A vendor that operations with their SCR systems have been in compliance and that there has been no issue relative to load following.

We hope you will find this information useful.

Sincerely,

A handwritten signature in black ink, appearing to read 'M. Wolfe', with a long horizontal flourish extending to the right.

Mark R. Wolfe

MRW:bh
Attachments

April 1, 2002

Page 4

10 copies sent via Federal
Express to Docket Control
For filing this 1st day of April, 2002.

COPIES or the foregoing
Mailed this 1st day of
April, 2002, to:

Chairman William A. Mundell
Arizona Corporation Commission
1200 West Washington
Phoenix, AZ 85007
VIA FEDERAL EXPRESS

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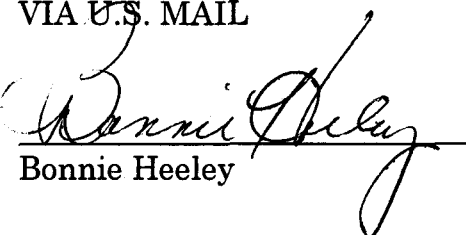
April 1, 2002

Page 5

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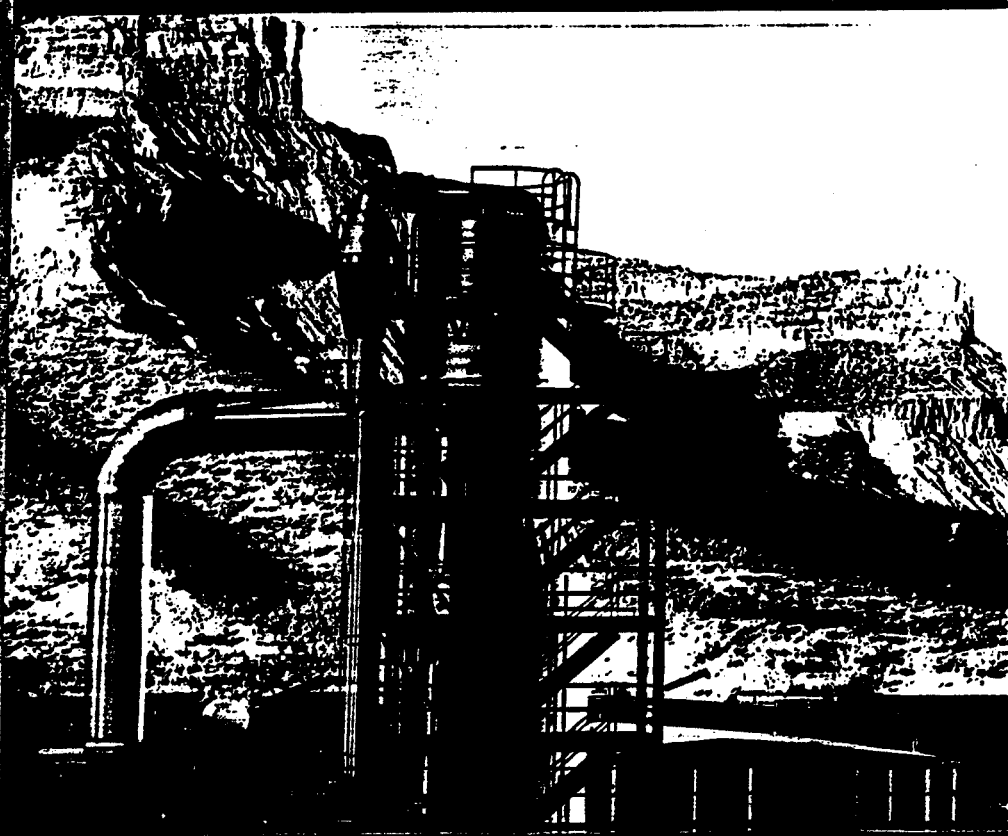
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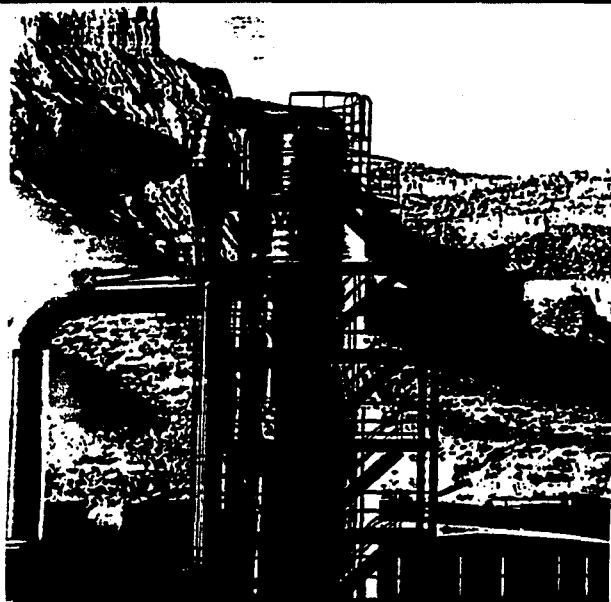
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Bonnie Heeley

Industrial Wastewater Recycling

Eliminate
Concentrations
from
Resources
Conservation
Company





This RCC Brine Concentrator in Utah has been operating since 1974, recycling 200 gpm of cooling tower blowdown and demineralizer waste. Brine Concentrators are designed to last 30 years; corrosion-resistant titanium and high-grade materials are used in vessel fabrication.

Turn wastewater into pure water and use it again.

The RCC Brine Concentrator turns salty industrial wastewaters into distilled water for recycling. Typically 95% of a wastewater can be recovered as high purity distillate, <10 ppm TDS. The remaining 5%, a concentrated slurry, may be sent to a small solar pond or reduced to dry solids in a crystallizer or spray dryer.

Brine Concentrators recycle:

- Cooling tower blowdown
- Demineralizer waste
- Reverse osmosis reject
- Electrodialysis reject
- FGD wastewaters
- Boiler blowdown
- Softener waste
- Plant drains
- Salty effluents
- Mine drainage
- Landfill leachate

Distillate is used for:

- Boiler makeup
- NO_x control
- Cooling tower makeup
- Process use

Waste brine is sent to:

- Small solar pond
- Crystallizer
- Spray dryer
- Ash wetting

Brine Concentrator benefits

Scale control

Brine Concentrators operate about one year between cleanings. RCC proprietary seeded slurry technology controls scale.

Patented brine distributors

"Twin spin" distributors ensure a smooth flow of brine, avoiding scale formation.

Variable waste flows

Our largest single Brine Concentrator treats 600 gpm; small units treat as little as 10 gpm.

Energy efficient operation

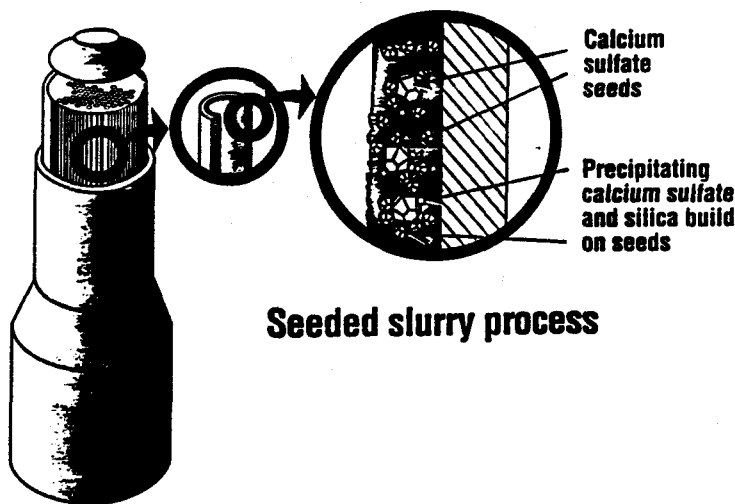
In the vapor compression configuration, the Brine Concentrator uses 29 to 37 BTU per pound of waste feed. This converts to 70 to 90 kWh per 1000 gallons of feed, 10 times more efficient than conventional single effect steam-driven evaporators.

Runs on electricity or steam

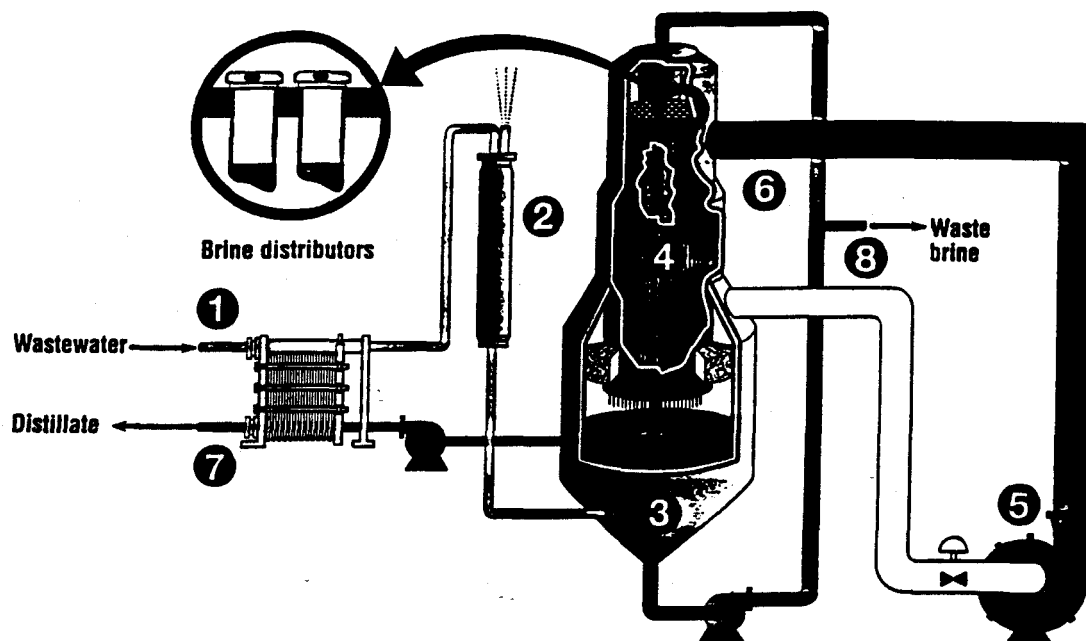
Brine Concentrators typically operate by mechanical vapor compression. However, they may also run on steam in a multiple effect configuration.



RCC designs powerful color graphic control systems for Brine Concentrators. These systems do not require a control room and may be installed on a desktop or in a weatherproof enclosure on site.



Seeded slurry process



Brine Concentrator process flow

- 1** The wastewater enters a feed tank (not shown) where the pH is adjusted between 5.5 and 6.0 for deaeration and decarbonation. The acidified wastewater is pumped through a heat exchanger that raises its temperature to the boiling point.
- 2** Wastewater passes through a deaerator which removes non-condensable gases such as oxygen and carbon dioxide.
- 3** Hot feed combines with the brine slurry in the sump. The brine slurry is constantly circulated from the sump to a floodbox at the top of a bundle of heat transfer tubes.
- 4** Some of the brine evaporates as it flows in a falling film down through the heat transfer tubes and back into the sump.
- 5** The vapor passes through mist eliminators and enters the vapor compressor. Compressed vapor flows to the *outside* of the heat transfer tubes.
- 6** Heat from the compressed vapor is transferred to the cooler brine falling inside the tubes, causing some of the brine to evaporate. As the compressed vapor gives up heat, it condenses as distillate.
- 7** The distillate is pumped back through the heat exchanger, where it gives up heat to the incoming wastewater.
- 8** A small amount of waste brine is blown down from the sump to control the brine density.

Various wastewaters treated by RCC Brine Concentrators

Cooling tower blowdown

Calcium	400
Magnesium	400
Sodium	1,320
Sulfate	4,762
Chloride	207
Bicarbonate	300
Silica	200
Total dissolved solids	7,589

Deionizer waste plus RO and EDR reject

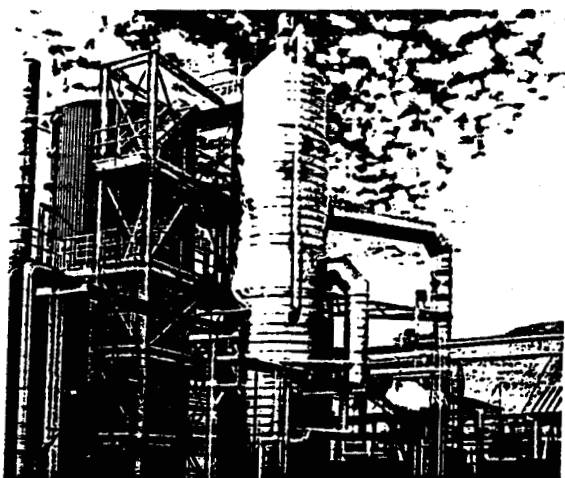
Sodium	2,774
Calcium	137
Magnesium	26
Chloride	829
Iron	1
Potassium	151
Sulfate	4,816
Nitrate	324
Silica	89
Bicarbonate	308
Manganese	1
Phosphate	94
Total dissolved solids:	9,464

Coal mine drainage (preconcentrated by RO)

Sodium	32,815
Potassium	422
Magnesium	1,007
Calcium	1,186
Barium	0.25
Strontium	13
Iron	1
Silica	24
Ammonium	21
Chloride	53,138
Bicarbonate	1,045
Sulfate	3,700
Fluoride	2
Total dissolved solids:	93,500

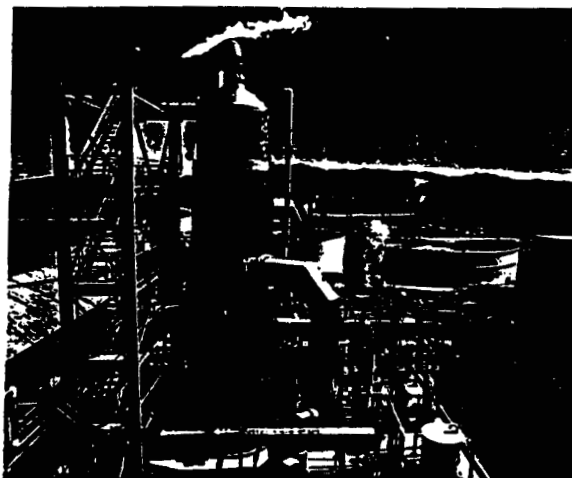
How industry is using RCC Brine Concentrators

Cogeneration Plant, California



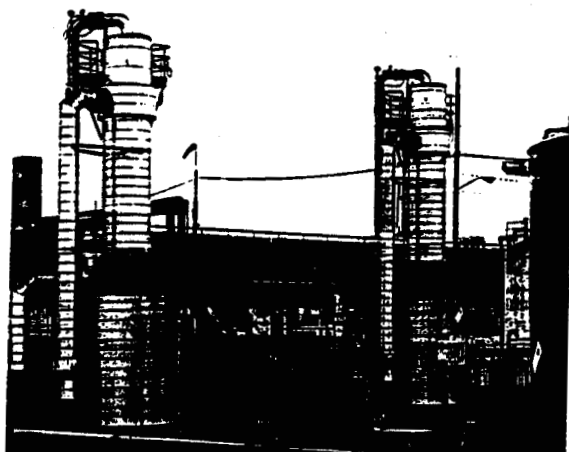
Brine Concentrator recycles 150 gpm of cooling tower blowdown, demineralizer waste, softener waste and boiler blowdown, recovering 142 gpm of distillate for boiler and cooling tower makeup. Waste brine goes to a spray dryer (left), which produces dry solids for disposal.

Copper Smelter, New Mexico



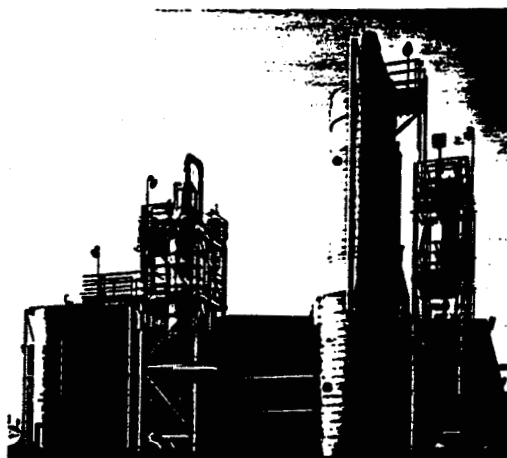
Brine Concentrator recycles 220 gpm of cooling tower blowdown, reclaim pond blowdown and process water, recovering 209 gpm of distillate for boiler and cooling tower makeup. Waste brine goes to a solar pond.

Chemical Manufacturer, Nevada



Two Brine Concentrators recycle 50 gpm each of cooling tower blowdown and process wastewaters, recovering 95 gpm of distillate for boiler makeup. Waste brine goes to a solar pond.

Combined Cycle Power Plant, Virginia



Brine Concentrator recycles 90 gpm of demineralizer waste, reverse osmosis reject and electro dialysis reversal reject, recovering 85 gpm of distillate for boiler makeup. Waste brine goes to a crystallizer (left), which produces dry solids for disposal.

Give us a call.

With more than 60 Brine Concentrators in operation since 1974, RCC is the industry leader in wastewater recycling. For details, please call, fax or write.



RCC Resources
Conservation
Company

3006 Northup Way
Bellevue, WA 98004-1407

Phone: 425 828-2400
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Reducing

Wastewater

to Solids

Crystallizers

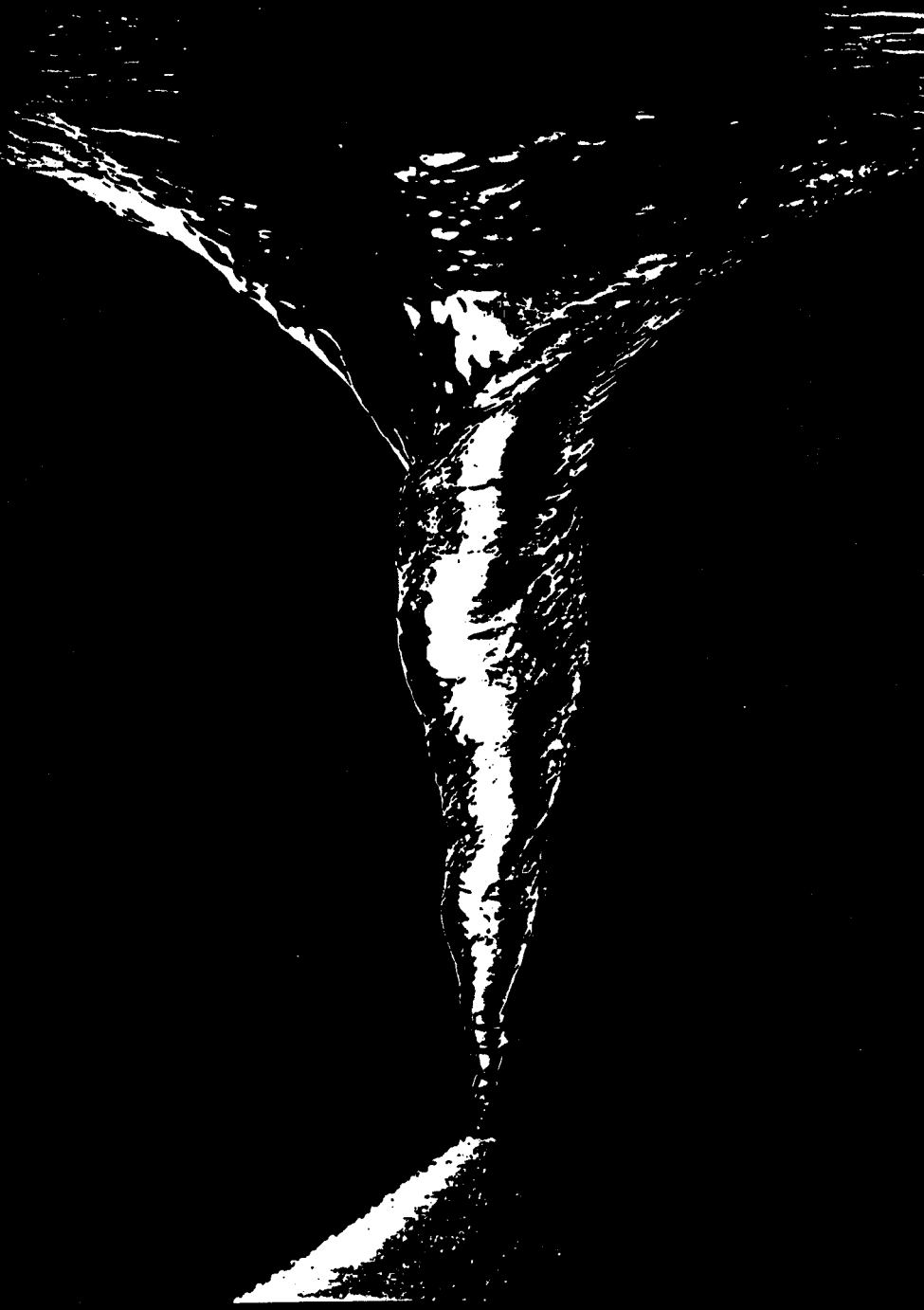
from

Resonances

Conservation

Company

EXHIBIT
INTC-304





Now you can reduce all your wastewater to dry solids.

At last—no more wastewater. Just solid crystals and clean water. That's what you need to meet stringent zero liquid discharge requirements.

With an RCC Crystallizer, your wastewater problem literally evaporates. You are left with a solid cake that is easy to handle. Water recovered from your waste stream is distilled and may be recycled back to the plant.

An RCC Crystallizer in Poland (left) recovers pure NaCl from a highly saturated mixed-salt wastewater.

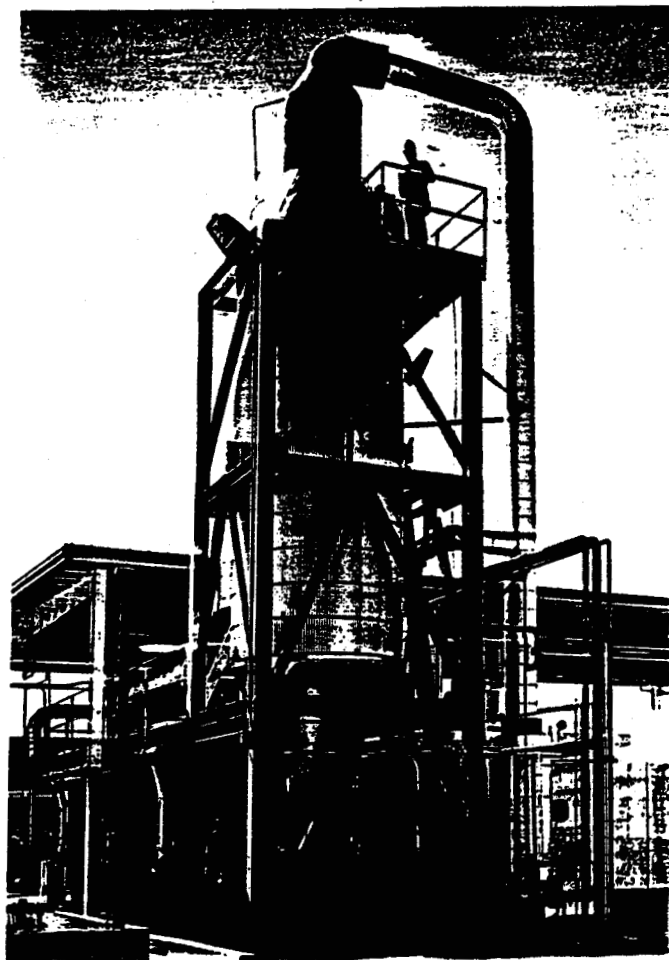
Crystallizer Benefits

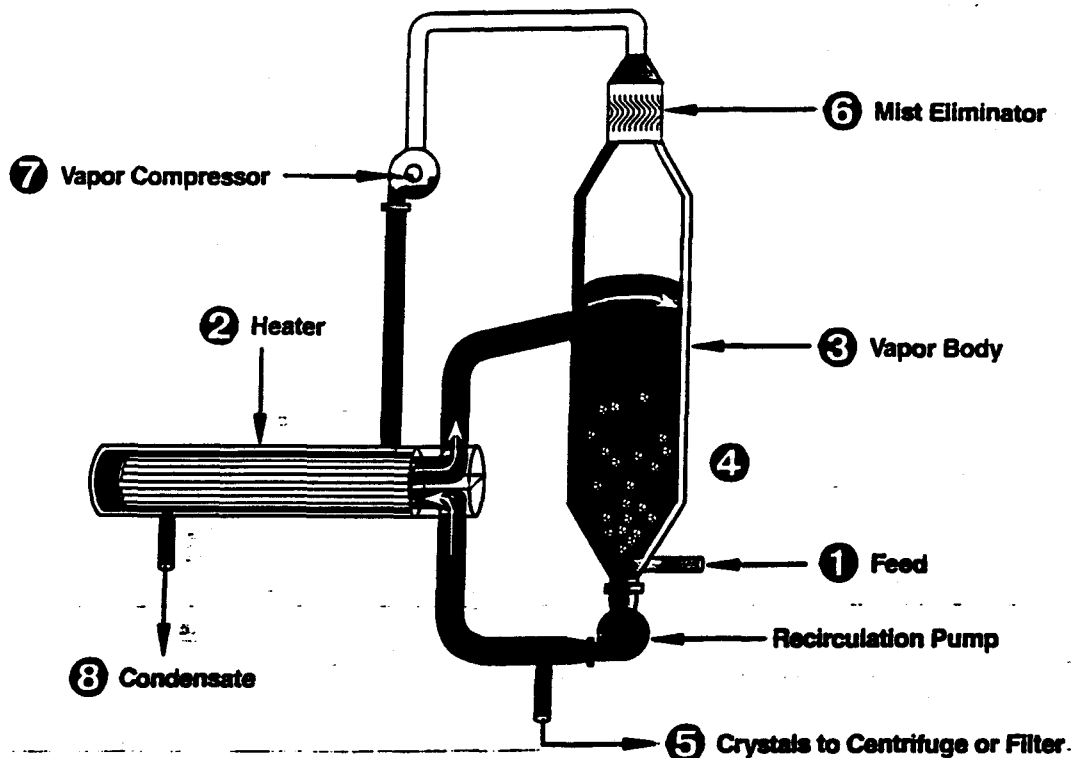
- Easy to use.**
 With simple color graphic controls and automatic wash systems, RCC Crystallizers are easy to operate.
- Easy to install.**
 RCC Crystallizers are generally skid-mounted and fully packaged with all auxiliary equipment and controls.
- Recovers valuable products.**
 RCC Crystallizers can be designed to recover specific salts from a waste stream.
- RCC: the experts in zero liquid discharge.**
 Since 1971, RCC has been designing and perfecting technology to solve zero discharge problems worldwide. RCC has installed more than 60 zero discharge wastewater treatment systems for a variety of industries including power generation, chemical processing, pulp and paper, mining and smelting.



RCC designs powerful color graphic control systems for Crystallizers. These systems do not require a control room and may be installed on a desktop or in a weatherproof enclosure on site.

A skid-mounted Crystallizer (right) at a zero discharge site in California reduces hazardous waste to solids for disposal at a secure landfill.





Forced-Circulation, Vapor Compression Crystallizer Process Flow

- ① Wastewater is pumped to the crystallizer.
- ② Wastewater joins the recirculating brine and is pumped to a shell and tube heat exchanger (heater). Because the tubes are flooded, the brine is under pressure and will not boil. This prevents scaling in the tubes.
- ③ The recirculating brine enters the crystallizer vapor body at an angle, where it swirls in a vortex. A small amount of the brine evaporates.
- ④ As water is evaporated from the brine, crystals form.
- ⑤ Most of the brine is recirculated back to the heater. A small stream from the recirculating loop is sent to a centrifuge or filter to separate remaining water from the crystals.
- ⑥ The vapor from evaporation passes through a mist eliminator to remove entrained particles.
- ⑦ The vapor is compressed in a vapor compressor. The compressor vapor heats the recirculating brine when it condenses on the shell side of the heater. (Plant steam can also be used to heat the slurry.)
- ⑧ Condensate is collected and may be recycled to other processes requiring high quality water.

Typical wastewaters treated by RCC Crystallizers

Demineralizer Waste

1.6 gpm from Brine Concentrator	
Calcium	800 ppm
Magnesium	900
Sodium	41,300
Sulfate	49,600
Chloride	31,100
Total Dissolved Solids	124,000
Total Suspended Solids	57,000

Chemical Waste

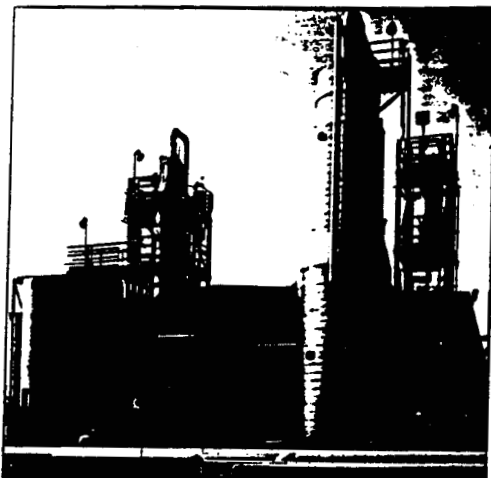
15 gpm	
Calcium	2 ppm
Magnesium	1
Sodium	23,600
Sulfate	13,500
Chloride	9,600
Fluoride	1,140
Carbonate	5,800
Nitrite	8,000
Nitrate	370
Acetate	2,000
TOC	2,300
Total Dissolved Solids	66,500

Coal Mine Drainage

225 gpm from reverse osmosis/ Brine Concentrator system	
Calcium	2,400 ppm
Magnesium	2,800
Sodium	42,300
Potassium	1,175
Sulfate	10,400
Chloride	148,000
Nitrate	280
Silica	67
Total Dissolved Solids	258,000
Total Suspended Solids	3,000

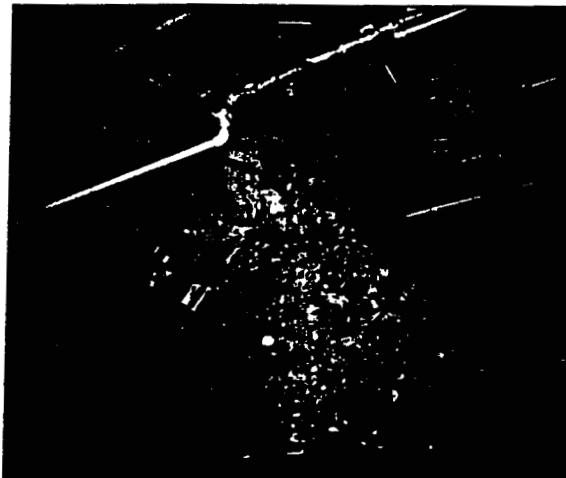
How industry is using RCC Crystallizers

Combined Cycle Power Plant, Virginia



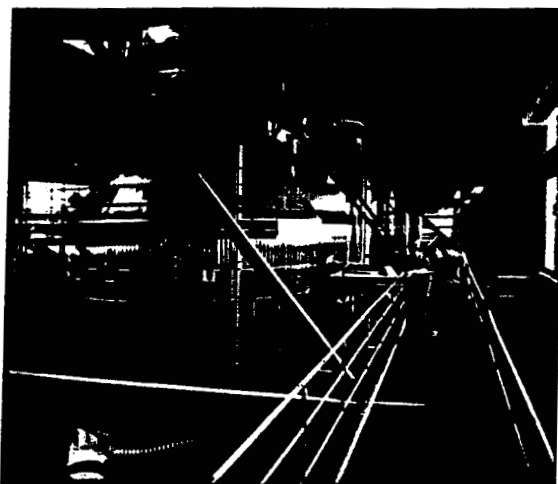
Waste from the RCC Brine Concentrator is sent to a five gpm crystallizer, (left) which produces dry solids.

Cogeneration Plants, Florida



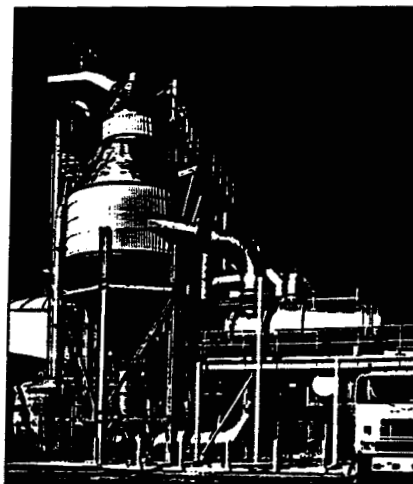
Calandria crystallizers at three cogeneration plants treat three gpm each of concentrated brine, producing dry solids.

Coal Mine, Poland



A 225 gpm crystallizer treats waste from two RCC Brine Concentrators, recovering about 300 tons per day of pure sodium chloride for sale throughout Europe.

Cogeneration Plant, Florida



Waste from two RCC Brine Concentrators is treated in a 50 gpm crystallizer, producing dry solids for disposal.



RCC Resources
Conservation
Company

3006 Northup Way
Bellevue, WA 98004-1407

Phone: 425 828-2400
Fax: 425 828-0526

Zero Liquid Discharge Industrial Plants Using RCC Brine Concentrators, Evaporators, and Crystallizers



RCC Resource
Conservation
Company

D = Process & Equipment Design
C = Construction

E = Equipment Procurement (& Supply)
S = Commissioning & Startup Services

Client	Plant	Location	Startup	GPM	Industry	* Scope			
			Year			D	E	C	S
Salt River Project	Navajo	Arizona	1974-80	1400	Power	X	X	X	X
Utah Power & Light	Huntington	Utah	1974	200	Power	X	X	X	X
Public Service Company of N.M.	San Juan	New Mexico	1974-84	3300	Power	X	X	X	X
Public Service Co. of Colorado	Hayden	Colorado	1976	250	Power	X	X	X	X
Montana Power	Colstrip	Montana	1977	350	Power	X	X	-	X
Tri State Generation & Trans.	Craig	Colorado	1978	700	Power	X	X	X	X
Arizona Public Service	Four Corners	Arizona	1979	400	Power	X	X	-	X
Public Service . of Colorado	Pawnee	Colorado	1980	450	Power	X	X	-	X
City of Colorado Springs	R.D. Nixon	Colorado	1980	350	Power	X	X	-	X
Otter Tail Power	Big Stone	South Dakota	1980	600	Power	X	X	X	X
City of Gainesville-Alachua County	Deerhaven	Florida	1981	300	Power	X	X	X	X
Northwest Alloys	Addy	Washington	1981	80	Magnesium	X	X	X	X
Texas Utilities	Monticello	Texas	1982	250	Power	X	X	X	X
Nevada Power	Clark	Nevada	1982	600	Power	X	X	-	X
Texas Utilities	Martin Lake	Texas	1983	500	Power	X	X	-	X
SASOL	Secunda	South Africa	1983	1800	Synth. fuel	X	X	X	X
Asarco	Hayden	Arizona	1984	200	Copper Smt.	X	X	X	X
Southern California Edison	Mojave	Nevada	1985	600	Power	X	X	-	X
IBM	Tucson	Arizona	1985	100	Electronics	X	X	X	X
Pacific Power	Bayswater	Australia	1986	1200	Power	X	X	X	X
Los Angeles County	Pitchess	California	1988	150	Power	X	X	-	X
Thermo Electron Corporation	Mendota	California	1988	38	Power	X	X	-	X
CRS Serrine	Stratton	Maine	1988	20	Power	X	X	-	X
Texas New Mexico Power	Bremond	Texas	1989	322	Power	X	X	-	X
Kerr-McGee Chemical Corporation	Henderson	Nevada	1989	100	Chemical	X	X	-	X
National Energy Constructors	Hanford	California	1989	75	Power	X	X	-	X
Sask Power	Shand	Saskatchewan	1990	322	Power	X	X	-	X
Aerofet	Sacramento	California	1990	15	Chemical	X	X	-	X
Harbert International	Tracy	California	1990	50	Power	X	X	-	X
Westinghouse/	Bellingham	Massachusetts	1991	30	Power	X	X	-	X
Fluor Daniel/Doswell Utilities	Doswell	Virginia	1991	90	Power	X	X	-	X
Walsh Construction	Mecca	California	1991	50	Power	X	X	-	X
Asarco	El Paso	Texas	1991	150	Copper Smt.	X	X	X	X
Millar Western Pulp	Meadow Lake	Saskatchewan	1991	2200	Pulp	X	X	-	X
Pacific Pwr/ Rolls Royce Ind. Pwr.	Mt. Piper	Australia	1991	1266	Power	X	-	-	X
Phelps Dodge	Hidalgo	New Mexico	1991	200	Copper Smt	X	X	-	X
Coastal Chem	Cheyenne	Wyoming	1991	150	Chemical	X	X	-	X
Cydsa Celulosa y Derivados	Guadalajara	Mexico	1992	156	Acrylics	X	X	-	X
Orlando Utilities Commission	Stanton	Florida	1993	600	Power	X	X	-	X
No. Canadian Power & Peoples Cogen/ Zurn/Nepco	Lake	Florida	1993	3	Power	X	X	-	X
Pasco Cogen/Zurn/Nepco	Pasco	Florida	1993	3	Power	X	X	-	X
Mission Energy	Auburndale	Florida	1993	130	Power	X	X	X	X
New York State Gas & Electric	Milliken	New York	1993	30	Power	X	X	-	X
Bechtel/U.S. Generating Co.	Cedar Bay	Florida	1993	300	Power	X	X	-	X

Zero Liquid Discharge Systems
Using RCC Brine Concentrators, Evaporators, and Crystallizers



RCC Resource Conservation Company

D = Process & Equipment Design
C = Construction

E = Equipment Procurement (& Supply)
S = Commissioning & Startup Services

Client	Plant	Location	Startup Year	GPM	Industry	D	E	C	S
Australian Forest Industries	Myrtleford	Australia	1993	220	Pulp	X	X	-	X
Polish Coal Mine/Nordcap	Debiensko	Poland	1994	835	Coal	X	X	-	X
Bechtel/U.S. Generating Co.	Indiantown	Florida	1994	580	Power	X	X	-	X
Apache Nitrogen	Benson	Arizona	1994	90	Fertilizer	X	X	X	X
Zurn/Nepco/	Bartow	Florida	1994	3	Power	X	X	-	X
Japanese Gas Corporation	Hanford	Washington	1994	20	Nuclear Pwr.	X	X	-	X
Resources Technology Group	Weldon Spring	Missouri	1995	50	Raffinate Pit Cleanup	X	X	-	X
East Penn	Lyon Station	Pennsylvania	1995	100	Battery Manf.	X	X	-	X
Western Pwr/ Rolls Royce Ind. Power	Muja	Australia	1996	150	Power	X	-	-	X
DIAMO	Straz	Czech Rep.	1996	1600	Mining	X	X	X	X
Pasco County Municipality	N. Port Richey	Florida	1997	30	Ash landfill	X	X	X	X
Samsung	Pusan	Korea	1997	5	Electronics	X	X	-	X
U. S. Navy	Jacksonville	Florida	1997	3.5	Manf. Cleanup	X	X	-	X
Ocean State Power	Harrisville	Rhode Island	1997	150	Power	X	X	X	X
EMI/Stone & Webster	Tiverton	Rhode Island	1998	20	Power	X	X	-	X
Kurita - ANAN	ANAN Sanitary	Japan	1998	50	Sanitary	X	X	-	X
Atlatic for PEMEX	Cadereyta	Mexico	1998	116	Oil Refinery	X	X	-	X
Atlatic for PEMEX	Madero	Mexico	1999	185	Oil Refinery	X	X	-	X
PAK S.A.	Adamow	Poland	1999	440	Power	X	X	-	X
Japan-Canada Oil Sands/(JACOS) MacDonald Engineering	JapAN-Canada Oil Sands	Alberta	1999	7	Heavy Oil Recovery	X	X	-	X
Confidential Paper Mill *	Confidential	No. America	2000	1800	Pulp & Paper	X	X	-	X
Tallahassee Elec./Raytheon Eng.	St. Marks	Florida	2000	230	Power	X	X	-	X
CFE/ABB Power	Monterrey	Mexico	2000	20	Power	X	X	-	X
Confidential Power Plant *	Confidential	USA	2000	400	Power	X	X	-	X
Calpine/Bechtel	Sutter	California	2000	380	Power	X	X	-	X
Texas Independent Energy	Guadalupe	Texas	2000	** 400/6600	Power	X	X	X	X
Aquila Utilicorp/Black&Veatch	Aries Power	Missouri	2000	280	Power	X	X	-	X
AES	Ironwood	Pennsylvania	2001	200	Power	X	X	X	X
PG&E Generating	LaPaloma	California	2001	** 600/5700	Power	X	X	X	X
Confidential Power *	Confidential	USA	2001	1,000	Power	X	X	X	X

* Confidential Power Plant at Customer's Request (To Be Announced)

** Larger value is size of the pretreatment system.

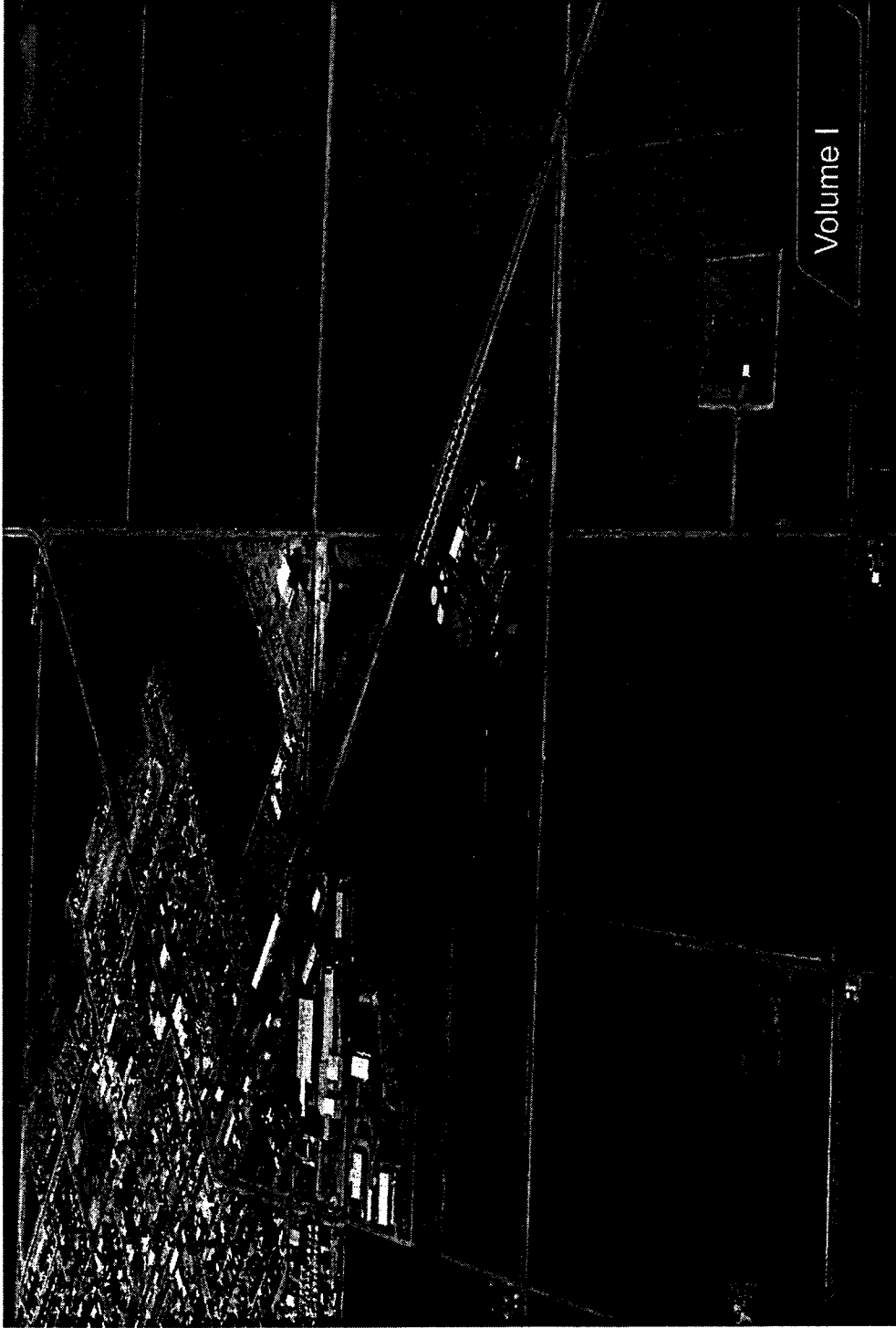
Application for Certification for

Central Valley Energy Center

San Joaquin, California

Submitted to:

California Energy Commission
Sacramento, California



October 2001

Applicant:

Central Valley Energy Center, LLC

SECTION 2.0

Project Description

2.2.9 Waste Management

Waste management is the process whereby all wastes produced at CVEC are properly collected, treated if necessary, and disposed of. Wastes include wastewater, solid nonhazardous waste, and hazardous waste, both liquid and solid. Waste management is discussed in more detail in Section 8.13.

2.2.9.1 Wastewater Collection, Treatment, and Disposal

The primary wastewater collection system will collect process wastewater from all of the plant equipment, including the HRSGs, cooling tower, and water treatment equipment. Since CVEC is a zero liquid discharge facility, process wastewater will be reclaimed and reused, to the extent possible. The leftover concentrated brine solution, high in total dissolved solids (TDS), will be dried in a drum dryer to a solid salt precipitate. The precipitate will be non-hazardous and be taken off-site for disposal in a municipal landfill, as described in Section 8.13. The water balance diagrams, Figures 2.2-6a and 2.2-6b, show the expected wastewater streams and flow rates for CVEC. The second wastewater collection system will collect sanitary wastewater from sinks, toilets, showers, and other sanitary facilities, and discharge it to the City of San Joaquin sanitary sewer system. The two wastewater systems are described below.

2.2.9.1.1 Circulating Water System Blowdown

Circulating water system blowdown will consist of reclaimed water from Fresno-Clovis WWTF along with various process waste streams that have been concentrated between three and eight times and residues of the chemicals added to the circulating water. These chemicals control scaling and biofouling of the cooling tower and control corrosion of the circulating water piping and condenser. Cooling tower blowdown will be discharged to a zero-liquid discharge treatment system, where most of the water will be reclaimed for reuse within the plant.

2.2.9.1.2 Zero Liquid Discharge Treatment System

The ZLD at CVEC makes use of three concentration steps – the cooling tower, a high TDS reverse osmosis system, and a brine concentrator. All process waste streams (oil/water separator effluent, quenched HRSG blowdown, and makeup reverse osmosis reject) are directed to the cooling tower for initial concentration. The cooling tower concentrates these streams near the mineral solubility limit for the constituents of concern (calcium and silica). This concentrated water must then be removed from the cooling tower via blowdown to prevent the formation of mineral scale in heat transfer equipment.

Cooling tower blowdown is stored to minimize flow variation in downstream ZLD equipment. After blowdown storage, cooling tower blowdown is passed through a multimedia filter to remove suspended solids. Suspended solids removal is required to minimize fouling of downstream ZLD equipment.

Cooling tower blowdown is near the mineral solubility limit for two components – calcium and silica. After filtration, the cooling tower blowdown is passed through weak acid cation resin to remove calcium. The weak acid cation resin is regenerated with sodium. The blowdown water then passes through a second weak acid cation vessel to remove the remaining calcium. Lowering calcium concentration prevents calcium scale formation in the high TDS reverse osmosis system. Waste from weak acid cation regeneration is neutralized and then sent directly to the brine concentrator feed storage tank for final concentration.

Although calcium-free, the treated cooling tower blowdown still contains silica concentrated to near the mineral solubility limit. Without treatment, this silica would form scale on the high TDS reverse osmosis membranes. Silica solubility, however, increases as pH increases. Thus, caustic is injected in

the cooling tower blowdown stream prior to the high TDS reverse osmosis system. Caustic injection raises the silica solubility limit and minimizes the potential for scale formation in the high TDS reverse osmosis unit.

High TDS reverse osmosis represents the second concentrating step in the ZLD system. The high TDS reverse osmosis unit recovers approximately 90 percent of the remaining cooling tower blowdown. Permeate from the high TDS reverse osmosis system contains low levels of silica and calcium. This relatively "good" water is returned to the cooling tower to minimize makeup water usage. The high TDS reverse osmosis reject, approximately 10 percent of the influent flow, contains high levels of silica and calcium. Since it is unusable in the plant, this small flow is directed to the brine concentrator for final concentration.

The brine concentrator receives high TDS waste from the weak acid cation vessels and the high TDS reverse osmosis reject. Heat is applied to evaporate approximately 96 percent of the water contained in these two waste streams. Evaporated water is reclaimed using a condenser. This distillate contains very little TDS. It is stored in a distillate storage tank, combined with makeup reverse osmosis permeate, and passed through a mixed-bed demineralizer (regenerated off-site). Demineralized water exiting the mixed bed demineralizer is stored in the demineralized water storage tank for use in the combustion turbines and HRSG steam cycle. The concentrated brine is sent to a drum dryer.

The drum dryer uses applied heat to accomplish evaporation to dryness. Dry, non-hazardous solids will be captured in bins and trucked off-site for disposal. Naturally occurring substances, such as trace heavy metals present in the cooling water, will become concentrated in the salt cake product from the ZLD system.

2.2.9.1.3 Plant Drains and Oil/Water Separator

General plant drains will collect area washdown, sample drains, and drainage from facility equipment areas. Water from these areas will be collected in a system of floor drains, hub drains, sumps, and piping and routed to the wastewater collection system. Drains that potentially could contain oil or grease will first be routed through an oil/water separator. Water from the plant wastewater collection system will be reclaimed to the cooling tower basin. Wastewater from combustion turbine water washes will be collected in a holding tank. If cleaning chemicals were not used during the water wash procedure, the wastewater will be discharged to the oil/water separator. Wastewater containing cleaning chemicals will be trucked offsite for disposal at an approved wastewater disposal facility.

2.2.9.1.4 Power Cycle Makeup Water Treatment Wastes

Wastewater from the power cycle makeup water treatment system will consist of the reject stream from the makeup reverse osmosis (RO) units that will initially reduce the concentration of dissolved solids in the plant makeup water before it is treated in the mixed bed ion exchange vessels and backwash water from the multi-media filters upstream of the RO units. The RO reject stream will contain the constituents of the reclaimed water, concentrated approximately four times; residues of the chemicals such as aluminum sulfate, ferric chloride, and polymer added to the reclaimed water to coagulate suspended solids prior to filtration; sodium bisulfite or sodium sulfite added to the RO feedwater to eliminate free chlorine that would otherwise damage the RO membranes; and phosphate to prevent scaling of the membranes. The filter backwash water will contain the suspended solids removed from the reclaimed water and residues of the coagulants used to enhance filtration efficiency. These waste streams will be collected and reclaimed to the cooling tower basin along with the plant drains and permeate from the high TDS RO units.

2.2.9.1.5 HRSG and Auxiliary Boiler Blowdown

HRSG blowdown will consist of boiler water discharged from the HRSG steam drums to control the concentration of dissolved solids and silica within acceptable ranges. Boiler blowdown will be discharged to flash tanks where the steam is vented to atmosphere and the condensate is cooled by

U₂A™ Urea-to-Ammonia “State of the Technology”

Prepared by Herbert W. Spencer III, James Peters and Jeff Fisher

EC&C Technologies, Inc. 4234 Chevy Chase Drive, LaCanada, CA 91011; Hamon Research-Cottrell, Inc., 58 E Main Street, Somerville, NJ 08876; Wahlco, Inc., 3600 Segerstrom Avenue, Santa Ana, CA 92704

ABSTRACT

This paper reviews the state of the technology for U₂A™ (Urea-to- Ammonia) with an emphasis on the test results from the AES demonstration, noting confirmation of key technical and operational details for the U₂A™ process.

INTRODUCTION

Utilities are increasingly adopting urea as the preferred alternative to anhydrous ammonia for their SCR projects. Utilities and A/E firms have shown keen interest in technology for urea-to-ammonia conversion. Several major utilities have committed projects to the urea-to-ammonia alternative and other major utilities have confirmed decisions to use urea and are actively evaluating systems for current and future projects.

After detail technical and economic evaluation, the EC&C Technologies U₂A™ system has been adopted for utility systems representing more than 8000 MW capacities.

The development of interest in urea-to-ammonia technologies is in response to the greatly increased requirements for utilities to control NO_x emissions and their implementation of SCR projects that require ammonia as the reducing agent at the catalyst.

Anhydrous ammonia is regarded as a hazardous and toxic chemical and is subject to strict regulations imposed by the EPA as well as OSHA.

Aqueous ammonia, although less concentrated, poses similar risks, and is also becoming increasingly regulated or subject to restrictions by local authorities. The use of aqueous ammonia as an alternative to anhydrous, significantly increases operating costs for chemical and energy, and increases transport and storage requirements. This is increasingly true as more dilute aqueous solutions are considered.

The Urea to Ammonia (U₂A™) system uses urea as the feedstock chemical and thereby entirely avoids risks associated with the transportation and storage of ammonia. The process transforms urea solution to an ammonia gas mixture that meets the dynamic requirements of the NO_x control system.

The ammonia equivalence of urea is approximately 50%. This makes it a lower operating cost chemical compared to aqueous ammonia and overall the best economic alternative where use of anhydrous ammonia is not desirable.

PROCESS

Process Development and U.S. Patent

U2A™ technology was developed by Emission Control & Chemical Technologies (EC&C) under grant sponsorship from the EPA's SBIR program.

As a result of the successful development work, EC&C made its initial filing with the U.S. Patent office on March 21, 1997. The patent was allowed in 1999 and issued as U.S. Patent 6,077,491 on June 20, 2000. Additional applications on the technology are pending

The earlier filing date and the strength of the patent claims provide strong protection for the U2A™ technology against competing processes.

Process Description

In the U2A™ process (U.S. Patent 6,077,491) urea solution is heated under controlled conditions to drive the thermal hydrolysis of urea to produce a product gas containing ammonia, carbon dioxide and water vapor. U2A™ is a once through process in which the hydrolysis reactor comes to a dynamic equilibrium with a water-rich reactor liquid compared to the feed solution.

The U2A™ reactor is a kettle-reboiler style "BKU" heat exchanger constructed from 316L stainless to ASME code requirements. The vessel is rated at 300 psig and is fitted with a closed steam U-coil for heat input. Heat is provided by a nominal 150-250 psig steam supply and the U2A™ reactors operate typically at 80 psig and 300° F.

The urea hydrolysis reaction proceeds from urea solution (excess water) to ammonium carbamate and then to ammonia, carbon dioxide and water vapor according to the following:



The overall reaction is endothermic and is easily controlled by regulating the heat input such that the reactor operates at constant gas pressure, which simplifies the control system to three primary PID loops. A demand signal based on NOx control requirements regulates flow of ammonia gas to the process via a flow control valve. A level controller adjusts urea solution feed to maintain constant liquid level in the reactor. A constant gas pressure of product gas is maintained by controlling the steam input to the heating coils.

U2A™ Operations at AES/Alamitos

The first commercial scale U2A™ system was started up in October 2000 at AES Alamitos station to provide ammonia to their existing SCR as a full-scale demonstration project. The operation at AES Alamitos was a complete success, leading to formal acceptance by AES and a contract for permanent installation of two U2A™ reactors at their Huntington Beach Station for operation starting in the summer of 2001.

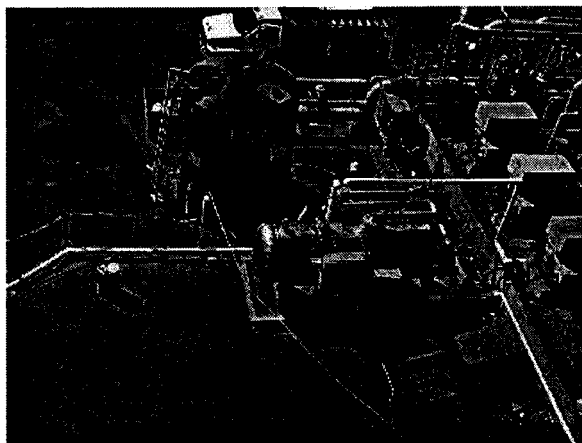
The U2A™ reactor at AES/Alamitos operated for approximately 1500 hours following system load in fully automatic controlled operation to meet SCR process demand requirements. During the operation of the unit, NO_x reduction ranged from 87-95% and was always in compliance. Procedures for start-up, shutdown, and idle mode were demonstrated. In side-by-side tests at full load, the U2A™ system demonstrated equivalent performance vs. the original aqueous ammonia system in place at Alamitos.

The reaction kinetics for U2A™, well understood at the pilot scale, were confirmed at Alamitos at full scale where the reactor operated within a few degrees of the predicted operating temperature vs. specific reaction rate. Predictive models support the designs for the U2A™ reactor and allow close prediction of reactor performance for various feed concentrations, temperature and pressures.

Operating time at Alamitos was sufficient to allow for quantitative and qualitative analysis of the expected residual from dissolved solids in the urea solution feed. This analysis together with physical inspection confirmed the suitability of materials of construction, the calculated requirements for periodic blowdown (annual or semi-annual), and the absence of accumulated organic materials (including carbon) in the reactor.

Tests were also conducted specifically to determine the fate of small amounts (0.2%wt) of formaldehyde that are typically present in prill and granular urea. These tests demonstrated that the formaldehyde is driven off to the flue gas and then destroyed across the SCR catalyst at removal levels of 90-95%.

Figure 1 Photograph of the AES Installation



U2A™ Urea-to-Ammonia "State of the Technology"

The U2A™ process is discussed below.

U2A™ Typical System Operation

Urea Receiving and Storage

Dry urea is received by either rail or truck delivery and transferred to bulk storage. For small capacity systems, commercial urea solutions can be used in lieu of dry urea.

Urea Solution Preparation

Urea is transferred from dry storage (or direct from delivery) to a dissolver tank. It is mixed with heated de-ionized water to make up a urea solution of nominal 40-50% concentration. The urea solution from the dissolvers is transferred to a feed tank.

Urea Reactor

Solution is pumped from the feed tank to the hydrolysis reactor to maintain a constant level in the reactor.

The hydrolysis reactor is a "kettle reboiler" type vessel designed to operate at up to 300 psig at 400°F. Normal operation is at 80 psig and approximately 300°F.

The reactor is operated at constant pressure and a PID control loop is used to control the feed rate of steam to the hydrolysis reactor to provide heat input to the endothermic reaction.

Start Up and Normal Operation

During commissioning, the reactor checkout is performed with de-ionized water. During initial start-up, urea solution is fed to the vessel and the reactor liquid is brought up to its equilibrium concentration during initial operations. During subsequent start-ups (from idle), the reactor already contains a near equilibrium solution.

As heat is input to the reactor, the solution temperature and pressure increases. When the reactor reaches about 235°F, the urea thermal hydrolysis reaction begins and ammonia and carbon dioxide gases are generated.

The pressure set point for the reactor is determined by consideration of the design rate for NH_3 production (a function of the temperature, solution feed concentration and reactor volume) and the equilibrium for the ammonia-water phase equilibrium at the design temperature and pressure (boiling point). The pressure must be set at a value above the boiling pressure in order that the desired reaction temperature can be achieved.

After start-up, the steam heat input continues in automatic control to maintain the gas pressure constant at the set operating pressure. The control valve on the product

ammonia gas line is opened or closed to match the required demand for ammonia as indicated by a 4 to 20 mA signal from the customer's control system.

Equilibrium Conditions

During normal operations the U2A™ reactor operates at near equilibrium conditions and the composition of the gases leaving the reactor and the feed composition closely matches the stoichiometric relationships of the urea hydrolysis reaction.

The composition of the reactor liquid contains water, dissolved urea, dissolved carbon dioxide and ammonia at a solution strength determined approximately by the phase equilibrium relationships for aqueous ammonia. The solution pH is typically 10.5.

At equilibrium the reactor liquid contains:

Ammonia - approximately 3% to 5% determined by phase equilibria

Carbon Dioxide - approximately 1% determined by solubility

Urea/Carbamate reaction intermediates – approximately 20%

Water - balance

Ramp up

When process demand for ammonia increases, the pressure control system increases the heat input to the reactor. As the temperature in the reactor rises, the rate of urea decomposition increases and ammonia can be withdrawn from the reactor at a faster rate while maintaining reactor pressure. The steam supply requirement and heat transfer equipment are sized to provide for a rate of increase in ammonia supply that is faster than the maximum ramp rate specified for the NOx control process.

Ramp down

Reduced demand from ammonia is satisfied by reduction in the heat input to the reactor, again at constant pressure. As the demand decreases the reactor temperature gradually decreases.

Normal shutdown

In a normal shutdown, urea solution feed is left on and heat input to the reactor is stopped. Residual heat in the reactor continues to evolve ammonia carbon dioxide and water vapor, which are bled off to the process. During the bleed off, the reactor pressure and temperature decrease. When the reactor temperature decreases to 240° F, the unit can be placed in idle mode, containing equilibrium solution for a subsequent restart. For

extended shutdowns or for servicing, the unit can be feed with DI water only and the urea/carbamate content of the reactor can be completely exhausted, such that the reactor will contains only water and blowdown materials.

Fast Shutdown

Auxiliary reactor cooling via the internal heat exchanger and/or from optional external coolers can be used to reduce the time required to cool the reactor and is used in certain upset conditions where ammonia gases can not flow to the flue.

Periodic Blowdown

A manually operated blowdown line is provided that can be used to drain off reactor solution in order to purge contaminants in the solution in the reactor. Based on using high purity DI water and typical urea (containing 20 ppm ash) blowdown requirements can be scheduled annually or semi-annually depending on load factor.

Ammonia Gas Delivery

The product gas is discharged through heat traced piping into the flue gas stream. The product gas line is maintained at a temperature above 300° F in order to avoid water condensation or reformation of ammonium carbamate solids.

Reactor sizing

In general, the following procedure is followed when sizing a U2A™ reactor:

The design basis includes the peak ammonia generation rate and the steam quality and cooling water available.

Specify a net liquid volume for the reactor vessel based on the reaction rate vs. temperature models, which define a specific ammonia production rate for the "boiling" temperature of the solution at the selected operating pressure.

Specify a vapor freeboard volume for the reactor vessel.

Specify a heat duty with allowance for ramping to meet the process dynamics.

Specify a cooling duty that satisfies the shutdown procedure time-temperature-pressure models.

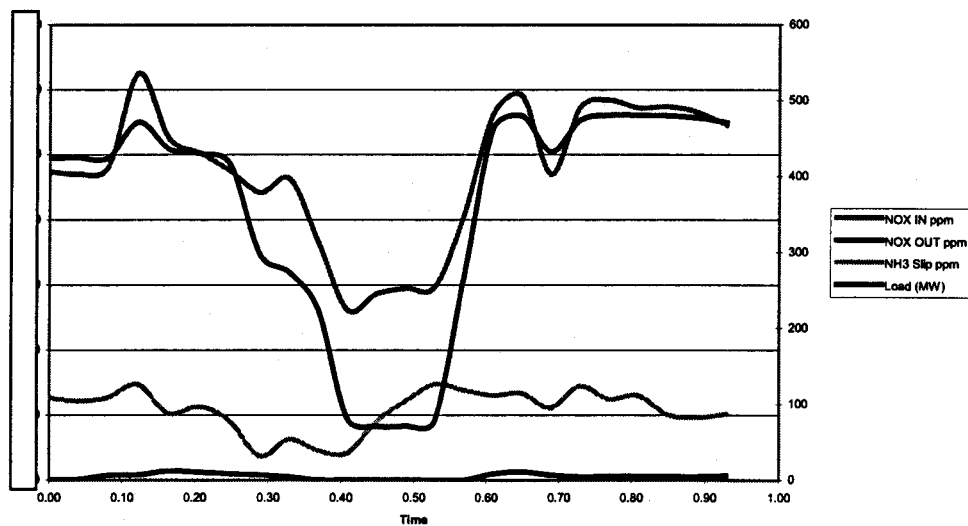
Determine the design of the heat transfer bundle to satisfy both the heating and cooling duty with the steam quality and cooling water given. For each specific case, either the heat duty or the cooling duty may control the design of the heat transfer bundle.

The sizing models for the design of the reactor were first developed during pilot demonstration work and are now confirmed from the operations at AES.

AES Demonstration Results

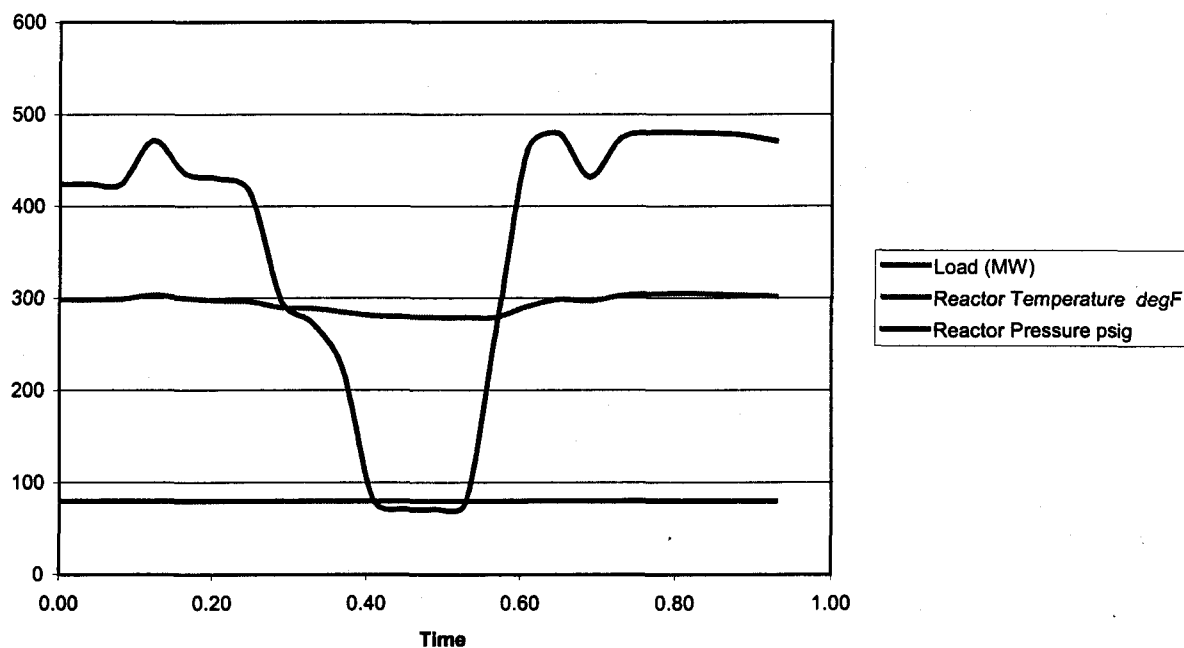
Test data representing operation of boiler and NOx SCR system (data points are hourly averaged information).

Figure 2 AES Operating Data, Load Scale Shown, the NOx and NH3 Slip Scale are suppressed.



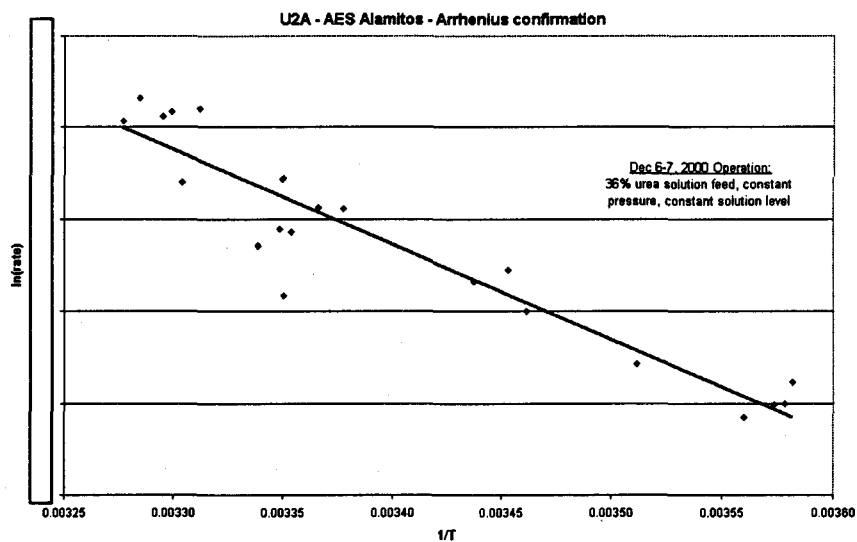
During this period the plant was operated to minimize NOx emissions to maximize the generation of NOx credits

Figure 3 AES Operating Data- Reactor Temperature and Pressure during Boiler Load Transition



Ammonia Generation

Figure 4 Reaction rate function of temperature

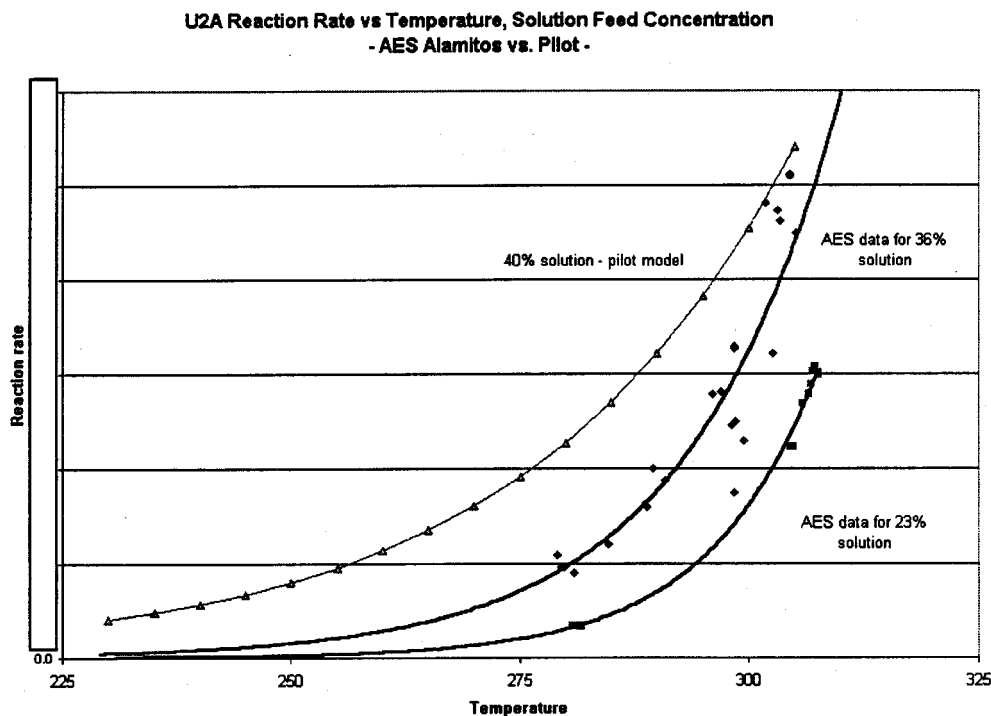


The U2A™ hydrolysis reaction is well represented by the Arrhenius relationships in which the log of the reaction rate is proportional to the inverse temperature.

Reaction rate dependence on feed concentration

The U2A™ reaction rate was observed at AES Alamitos for two solution concentrations and compared to pilot model correlations. The pilot correlation was run at 40% solution strength. There is a clear dependency of reaction rate on solution feed concentration.

Figure 5



Correlation vs. pilot performance model and scale up

The correlation showed good agreement between the operation of the AES reactor and the earlier pilot scale performance models. The AES data correlation will be used in reactor designs and while further scale up from this level does not require additional modeling, additional confirmation of the performance data will be obtained from the start-up of the larger reactors currently in construction.

Product Gas Composition

At the operating temperature and pressure of the reactor, the reactor gas contains ammonia, carbon dioxide and water vapor.

Since the U2A™ process operates at near equilibrium as a once-through process; the gas product leaving the reactor is at a known concentration that is the equivalent to the composition of the urea solution feed.

Urea solution concentration	wt%	40%	50%
U2A™ product gas			
Ammonia	vol%	28.5%	37.5%
Carbon Dioxide	vol%	14.3%	18.7%
Water Vapor	vol%	57.2%	43.8%

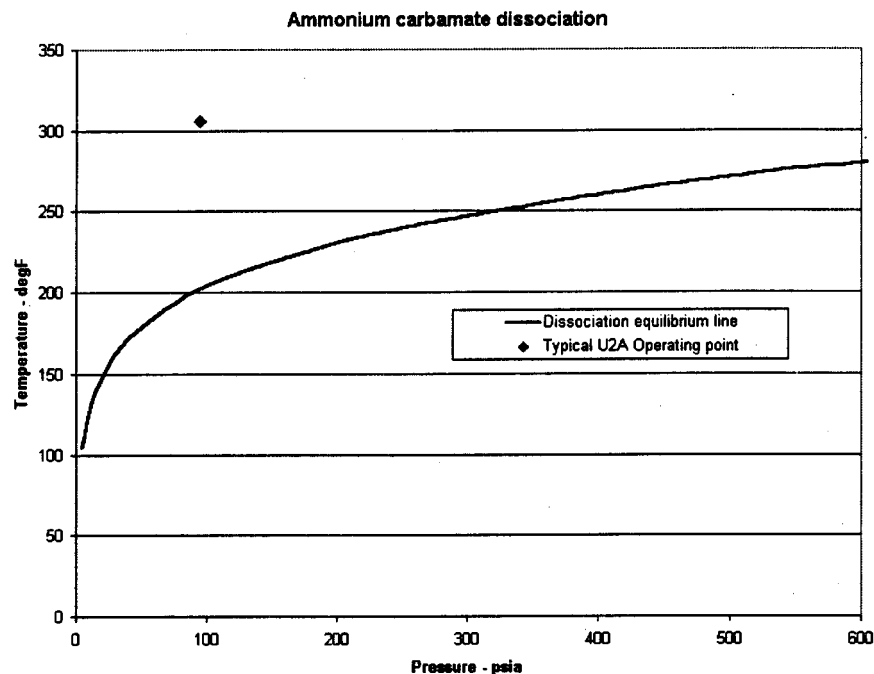
Operation with higher concentration urea solution reduces the throughput of water vapor through the system, while maintaining the volume proportion of ammonia to carbon dioxide at 2:1. The energy requirements for the process decreases while the reaction rate vs. temperature increases with higher urea concentration. With higher urea feed concentrations, more heat tracing is needed to prevent plugging of feed lines. In addition the feed concentration must have enough water to maintain excess water in the reactor for the hydrolysis reaction.

Ammonium Carbamate

The product gas piping from the reactors to the point of use must be maintained at temperatures and pressures that avoid both condensation of water and formation of ammonium carbamate.

The dissociation of ammonium carbamate is described in the following chart, which is derived from reference data (Kirk-Othmer). The typical operating point for U2A™ is shown in the region of the chart where the equilibrium prevents reformation of carbamate. In the region below the equilibrium line carbamate will begin to form as a solid fume that can deposit on surfaces.

Figure 6



Non-flammable mixtures

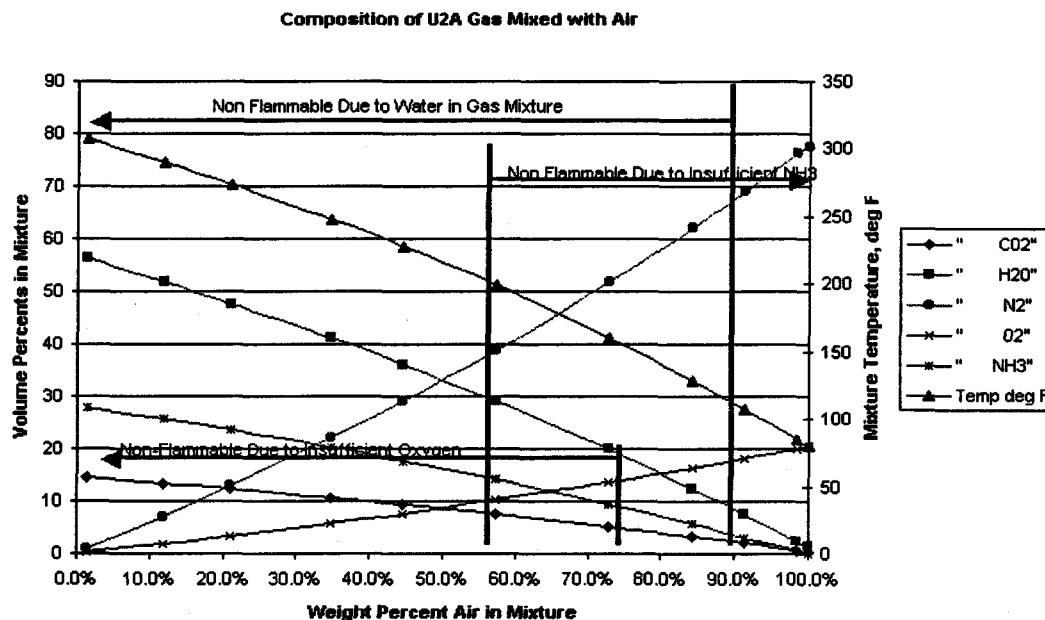
In most SCR systems, anhydrous or aqueous ammonia vapors are mixed with air to a point below the lower flammability limit of the mixture. Typically the mix is kept at less than 5% by weight ammonia in air.

The available data shows that all mixtures of the U2A™ product gas (for 40% urea solutions) with air are non-flammable.

The compositions of mixtures of the U2A™ gas (from 40% urea solutions) mixed with air (0 to 100 % by weight) are given in the graph shown below.

For mixtures with less than 75wt% air, the mixture is non-flammable due to the moisture content and due to insufficient oxygen to support combustion. For mixtures with greater than 57wt% air, the mixture is non-flammable due to insufficient ammonia. Since the regions overlap there is no mixture that is flammable. The temperature of the gas mixture is considered in setting the non-flammable region based on oxygen level.

Figure 7



Process Control

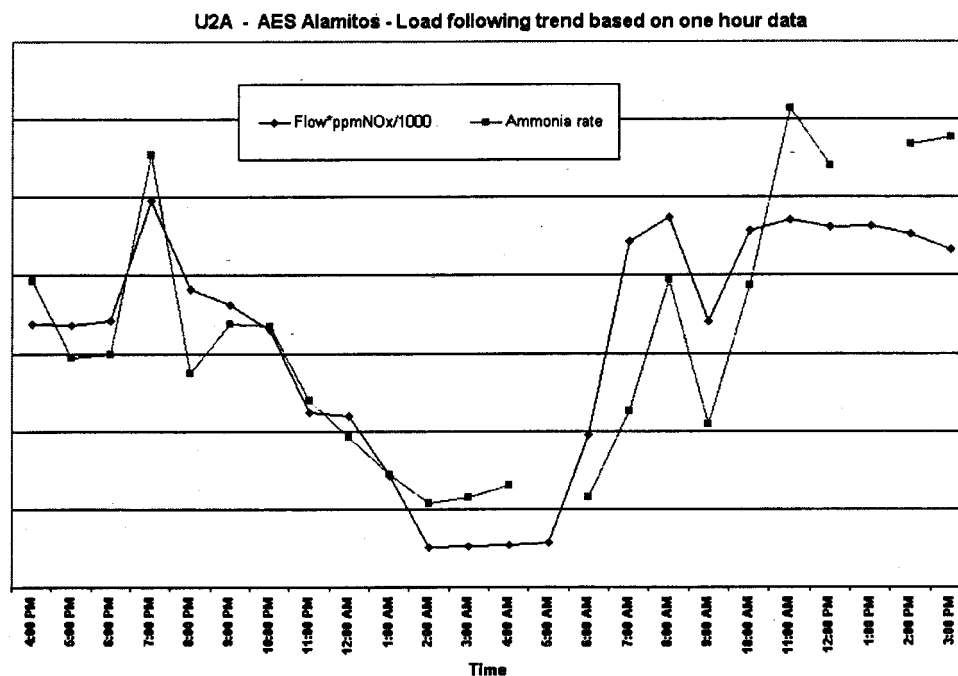
Load Following

The U2A™ process was operated in fully automatic mode at AES Alamitos Unit #6. This unit operates as a swing load unit with the SCR system in service over the full load range.

During automatic operation, the U2A™ system delivered ammonia gas to the SCR ammonia flow control units in response to the NO_x emissions control set points. At all times during U2A™ automatic control operation the NO_x emissions and NH₃ were maintained within compliance set points determined in the plant DCS.

The following plot illustrates the load following trend over a turndown range of approximately 10:1.

Figure 8

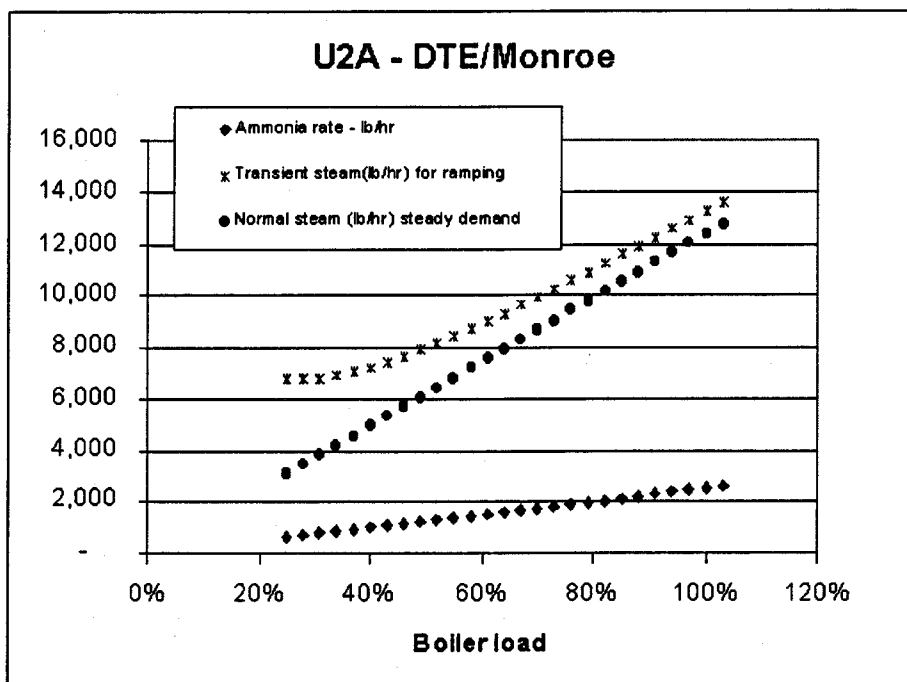


Ramping

The U2A™ process provides simple control and load following response including design to accommodate maximum ramping rates that are derived from consideration of the maximum rate of increase of boiler load, the flue gas mass flow vs. boiler load and the NOx concentration as a function of boiler load.

The heat exchanger design and the steam requirements consider the ramping rate requirement in the basic design, as is illustrated in the following example based on the system in design for the DTE/Monroe Station. Note that the requirements for steam flow during lower load operation compared to the steam capacity at full load will allow the system to ramp at rates much faster than the boiler will require.

Figure 9 Heat Input Requirements



The chart shows the expected steam consumption for one U2A™ reactor sized for 2500 lb/hr NH₃ based on:

Normal design per reactor of 2500 lb/hr ammonia from 40% urea solution at 100% load.

Assumption that ammonia demand is linear with boiler load.

Ramping is based on 75 lb/hr NH₃ per minute rate of change (3%/min).

Ramp rate applies across the entire load range shown.

Using 40% urea solution as the feed. Note that steam consumption can be reduced by feeding with 50% solution. Resulting consumption would be approximately 80%.

For one reactor at full load rating, expected steam consumption considering transient ramping requirements is 13,280-lb/hr of steam for 40% solution, and approximately 12,400 lb/hr normal.

This results in nominal steam consumption for four reactors of 49,600 lb/hr.

The mass balance submitted with a proposal will include a margin to account for steam pressure and/or temperature variation and to establish sizing for devices and piping. Steam loads for auxiliaries are determined separately.

Testing for SCAQMD

SCAQMD set as an objective for the AES demonstration that tests be conducted to demonstrate that the existing SCR system could be operated at performance levels of NO_x removal and show NH₃ slip than remained in conformance with the plant-operating permit.

Flue gas testing at AES

Stack tests at AES Alamitos were conducted by a certified third party testing firm in accordance with standard EPA methods, including:

NO_x

NH₃

Formaldehyde

The requirements of the SCAQMD were met. Liquid and residual samples were analyzed at a qualified third party laboratory. The test show comparable performance between aqueous ammonia and ammonia from U2A™. The test also showed that the ammonia from the urea feed to hydrolysis reactor was produced with a stoichiometric ratio of 1 as expected. The measured ratio was 1.02 based on averaged urea feed rates.

Reactor Inspection after Shutdown

After approximately 1500 hours of operation the AES reactor was returned to the original assembly site at Wahlco for inspection prior to final shipment to its permanent location at AES/Huntington Beach.

Visual inspection

Visual inspection of internal surfaces of the reactor and heat exchange bundle were made prior to removal of the reactor heat exchange bundle for close inspection. After this inspection the unit was water washed and the surfaces inspected again.

The visual inspection revealed a thin coating of silt like residual materials on the wetted surfaces of the reactor and on the upper surfaces of the heat exchanger tubes. On surfaces where liquid had flowed, as the vessel was empty, rivulet patterns were shown.

Samples of this material were taken for chemical analysis and the total quantity of the material was estimated.

Water washing easily removed all materials from the steel surfaces leaving a smooth shiny appearance.

A consulting metallurgist was retained to participate in the inspection. His report confirms the suitability of the materials of construction for the service conditions.

Residual material in the reactor

Residual materials are expected from non-volatile trace contaminant materials in the water or in the urea.

Total residuals

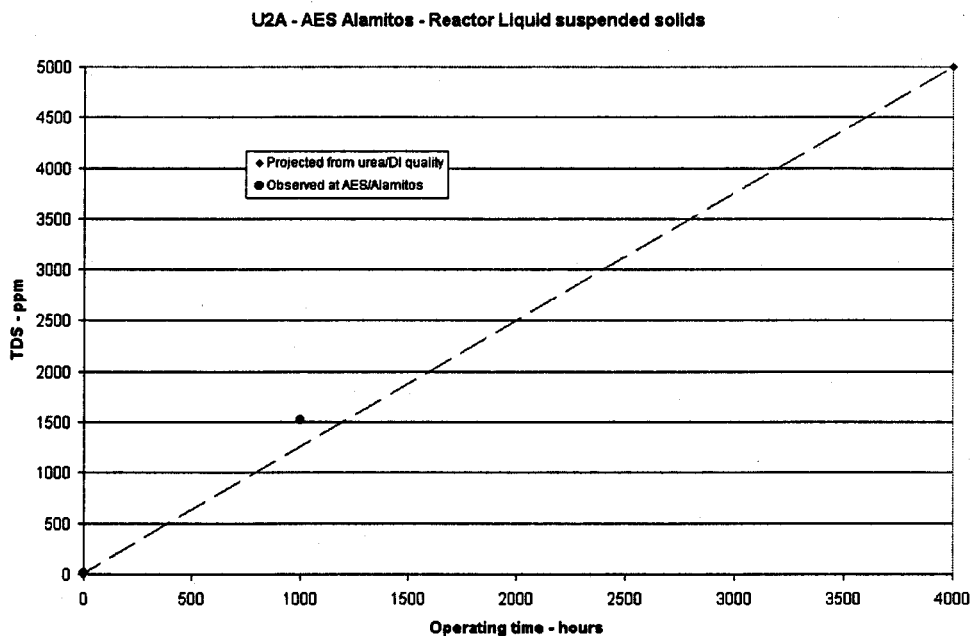
A total of approximately 25 to 50 lbs of brownish silt like particulate was found in the reactor. This amount is consistent with the buildup rate of suspended solids from the urea solution water quality. (Note that suspended solids are expected to reach about 0.5% after 4000 hours).

Organics

The total residual solids were analyzed for a total organic content and found to contain 4% total organics. Based on 50 lb total residual this amounts to 2 lb of organic content after approximately 1500 hours operation.

The low organic content further confirms that formaldehyde does not accumulate in the U2A™ reactor and that no decomposition to carbon occurs. Both formaldehyde and carbon are discussed separately.

Figure 10.



Materials of Construction – Metals Analysis of Residuals

The reactor vessel and heat exchanger are constructed from 316L stainless steel. This material was used in earlier pilot reactor development and found to be suitable. As part of the AES demonstration the residual material was analyzed for Fe, Cr, Ni and other metals as follows:

A material balance was calculated considering the time that the reactor was exposed to urea/carbamate solution and the total silt content. This allows an estimate of the rate of corrosion with respect to the corrosion allowance considered for the vessel design, which is based on 316L for both the vessel and the heat exchanger tubes.

The calculated life of the 0.025" corrosion allowance in the vessel shell that results from this analysis is in the range of 20 years or more based on the Cr and Ni content of the residuals.

Urea Quality

A typical urea specification lists:

Urea Specification Typical Analysis

Urea		99.0%
Moisture	0.3%max	0.15%
Biuret	1.2%max	1.0%
Formaldehyde		0.2%
Ash	20 ppm	15 ppm

The urea solution also must consider the TDS content of the water. DI water has a typical TDS content in the range 0.1 to 0.2 ppm.

Fate of Formaldehyde

In the U2A™ process, urea solution is hydrolyzed under heat and pressure to form ammonia, carbon dioxide and water vapor in a once through process that is controlled to meet the process demands typically for SCR and SNCR NOx reduction processed.

Questions regarding the fate of formaldehyde, present in urea, were addressed during the operation of the U2A™ system at AES/Alamitos station.

The experience for U2A™ indicates that formaldehyde, though present in the urea feed solution, does not accumulate in the hydrolysis reactor, but instead is driven off to the flue gas stream where it is readily oxidized by the SCR catalyst.

Formaldehyde in the flue gas

Levels of formaldehyde were measured in the flue gas stream both before and after the SCR catalyst for operation of the system with the aqueous ammonia system and the U2A™ system.

A net reduction in formaldehyde concentration across the SCR catalyst was measured in the range of 85%-95%. This result was checked with and is consistent with the expectations of a major SCR catalyst supplier (Ceram/Frauenthal). The head of their technical department advises that they would expect SCR catalyst to oxidize formaldehyde at high efficiencies.

No Carbon Formation

The presence of carbon residuals has not been observed in U2A™. This has been apparent through observation of the process in the pilot development and has been confirmed after 1500 hours operation at AES Alamitos by testing of the equilibrium reactor liquids and the residual materials analyzed after shutdown of the system.

Accumulation of non-volatile organics would necessarily be sensitive to urea quality and water quality issues. Specifications for urea quality must exclude non-volatile organics.

Decomposition of organics to carbon via "coking" is of concern only at temperatures much higher than is practiced in the U2A™ process. .

References

Cooper, H. B. H and Spencer, H. W., U.S. Patent 6,077,491 – Methods for the Production of Ammonia from Urea and/or Biuret, and Uses for NOx and/or Particulate Matter Removal.

Fenton, Donald L. et al., "Flammability Limits of Ammonia-Air Mixtures", presented at IAR 18th Annual Meeting, March 3-6, 1996. (The paper is available from the International Institute of Ammonia Refrigeration, 1200 19th Street, N. W., Washington, D. C. 20036-2401.)